SYNOPSIS OF THE THESIS ENTITLED

DEVELOPMENT OF REAL-TIME ALGORITHMS FOR HEALTH MONITORING SYSTEM USING WIRELESS SENSOR NETWORK

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➢ Abstract:

Healthcare industry has perpetually been on the forefront in the adoption and utilization of information and communication technologies (ICT) for the efficient healthcare administration and treatment. Recent developments in ICT and the emergence of wireless sensor networks and Internet of Things (IoT) have opened up new avenues for research and exploration in the all fields including medical and health care industry. The wireless sensor network within hospital premises or remote server connected nodes can be used to gather real-time data from non-invasive sensors. Proposed robust framework can have access to this data at any point in time and doesn't have to be physically present in the patient's room to review the readings. The sensor node detects the BPM (breaths per minute) to initiate a reading, then collects the data and forwards it to the base station. An attractive graphical user interface (GUI) was designed to store and display patient data on the base station PC. The set-up was found to be extremely robust with low power consumption.

In proposed architecture sensor modules are connected to one single low-cost micro-controller, which has capability to process real-time signals generated from bio-sensors and transmit through either patient's phone or any other means. This kind real time data will help to doctors to detect issues and solve them before disaster occurrence of remotely situated patient.

➢ Introduction:

Advances in wireless networking have opened up new opportunities in a variety of applications including healthcare systems. In fact, the healthcare market is among the fastest growing markets for WiFi and other Wireless Technologies [7]. The future will see the integration of the abundance of existing specialized medical technology with pervasive, wireless networks. One such example wherein future medical systems can benefit the most from wireless networks is continuous monitoring of patient with vital signs remotely. Many medical ailments can be monitored quite conveniently with the use of these networks within hospital premises. For example, the behavior of people suffering from sleep apnea can be monitored using on-body sensors to assess the severity and pattern of obstructive sleep apnea by monitoring their blood oxygenation, breathing, and heart-rate every night. Similarly, cardiac health can be monitored by keeping a track of a patient's heart-rate [5].

Abnormal heart rhythms can cause the heart to be less efficient, and can cause symptoms such as dizziness, fainting, or fatigue. Since they are sometimes very brief, it can be difficult to properly characterize them. Cardiac stress tests in the presence of a physician attempt to induce the event while the patient is wearing wired sensors in a laboratory. However, wearable electrocardiogram (ECG) sensors can monitor for the condition continuously, over days or weeks, until the event occurs. The recorded data can be promptly sent to the physician for analysis in real-time. If the event is serious enough, an emergency communication channel may be used to call for help, or it may be dispatched automatically.

Although present systems in hospitals or in-house ICUs allow continuous monitoring of patient vital signs, these systems require the sensors to be hardwired to nearby bedside monitors or PCs, and essentially confine the patient to his hospital bed. The advent of WiFi, Bluetooth and internet have facilitated breaking the cord between the non-invasive patient sensor and the bedside equipment [3]. These systems do not require the patient to be confined to his bed and allow him to move around freely in his room or house but requires him to be within a specific distance from the bedside monitor.

For example, the range of transmission for typical Bluetooth systems is about ten meters. Beyond this distance, it is not possible to acquire data. Patient mobility beyond his hospital room can be incorporated by using a network of such nodes placed at appropriate distances in order to transfer data to the monitoring station. However, network nodes that use protocols such as Bluetooth require a larger volume and higher power consumption. This indirectly indicates a higher cost per node and a fairly high burden on its power source further increasing its size and cost. Depending on the size of the hospital, several such nodes might be required resulting in a much higher system infrastructure cost. Moreover, such protocols are meant for moderate to high bandwidth applications where relatively large packets of data need to be transmitted and received. In the case of patient vital sign monitoring, the data packet size is much smaller which seems to suggest that networks using such protocols might seem impractical.

Obviously, low power, low cost network nodes are required for such applications. Wireless sensor networks (WSNs) consist of nodes that consume very low power and are extremely small in size. This facilitates easy integration with non-invasive biomedical sensors. These

network nodes are specifically designed for low power consumption and with minimal circuit components. They are intended for small packet, short distance range applications and typically consist of a low power processor with minimal resources and interface capabilities. They also have a conservative transceiver that is capable of transmitting only a few bytes of data at a time and has a moderate transmitting range of about ten meters. Therefore, WSNs seem to be a perfect fit for remote patient monitoring. This research will investigates the practicality of using WSNs for monitoring patient vital sign data.

- **Literature survey:**

Wireless health monitoring system (WHMS) has drawn considerable attentions from the research community as well as industry during the last decade. Numerous and yearly increasing research and development efforts have been posted in the literatures. We have limited his effort to include only some of the very recent related works. Real time mobile healthcare system for monitoring the elderly patients from indoor or outdoor locations has been presented in [9]. A bio-signal sensor and a smartphone are the main components of the system. The data collected by the bio-signal sensor are transmitted to an intelligent server via GPRS/UMTS network. The system is able to monitor the mobility, location, and vital signs of the elderly patient from a remote location.

Most mobile phones and personal computers are integrated with wireless network, therefore, it is useful to use these devices for medical data transfer. In this case, "the amount of time the doctors need to identify the problem, trace back the medication history of the patient and consult fellow doctors will be reduced significantly"[7]. Such a system requires to update the databases for patients by real-time sensing and monitoring of their health parameters. Using computers and wireless technology in healthcare monitoring will achieve many goals, such as diagnosis time, accuracy, number of patients, amount of paper work and many others. Applications of wireless sensor technology for healthcare monitoring enable doctors to monitor their patients anywhere and at any time without any physical constraints and without the need for the patient to stay in hospital.

Presently, in order to continuously track a patient’s BP and heart-rate over a period of time, physicians hand over specialized devices to patients as described in [3]. Most of these devices are cuff-based that are worn on the arm or wrist, and store patient data on their local memory over a period of time. The patient then takes the device back to his physician who

downloads the data from the device to his PC for analysis. Such systems, although extremely useful and necessary, suffer from lack of real-time monitoring. On counterpart, proposed system's sensor might detect an extremely high BP reading which can generate a local alarm at the patient vicinity, it is up to the discretion of the patient to inform his physician immediately rather than waiting for his next appointment. The proposed system can address such situations by routing data in real-time from a patient's home to a website database where the data can be accessed by his physician without any time lag. In this case, any dangerous situation can be avoided because the technology will generate an alarm to alert the physician rather than requiring the patient to inform his physician of the situation.

- **Objectives of research:**

This WSN based system provides following advantages: -

- **Lowered cost of care**: By leveraging WSN based health monitoring system, the health of patients can be monitored on a real time basis, avoiding unnecessary doctor visits. Home care is possible, further reducing hospital stay. Caregivers can address common use cases and reach out to doctors only when needed.
- **Improved patient outcomes**: By referring to a comprehensive knowledge base compiled from previous disease outbreaks and proven research, caregivers and doctors can use evidence-based medicine for improved patient outcomes. The real-time information can help provide timely care and address issues at an early stage.
- **Real time disease management**: In a connected healthcare environment with continuous remote monitoring, patients can get treated proactively before their condition worsens. This not only helps patients' health, but also reduces the cost of care. The focus is shifted from 'treatment' to 'wellness'.
- **Improved quality of life**: For the critically ill, pediatric and aged populations, WSN-HMS offers an easier life. The elderly can live independently at any location of their choice while getting their medical condition monitored. Improved user experience: For patients as well as caregivers, WSN-HMS makes it possible to have a richer and more intimate engagement with each other. Automation of data collection makes it possible to collect data accurately, on time and with minimal human intervention. All stakeholders or doctors receive better visibility with respect to the patient's

condition, progress and outcomes of treatment. Automation of engagement also allows better compliance to prescribed treatment regimes.

This research will try to overcome following limitations of WSN based health monitoring system:-

- **Scale, data volume and performance**: As the quality and accuracy of medical devices improve, more applications will be developed for an expanding user base. The amount of data that needs to be ingested, stored and analyzed will also increase exponentially. Some medical devices will need to store high resolution data, and some will generate multimedia output such as high resolution images and videos. This will lead to a typical Big Data problem where the sheer volume and velocity of data ingested will make standard architectures and platforms inadequate. In other cases, some applications may demand more stringent real-time performance than what is ordinarily possible using standard internet technologies. Applications and the database backend must be seamlessly scaled up as operations become more complex.
- **Flexibility and evolution of applications**: As newer analytics, techniques, algorithms, use cases and business models evolve, advanced medical devices with improved capabilities will be created. Newer applications and software components need constant upgrades by specialists with specific technology and medical domain skills.
- **Data privacy**: Data collected from medical devices is sensitive and must be protected from unauthorized access. It should be used only for the specific purpose for which the patient/user allowed that data to be collected. Policies to share medical data with authorized persons and applications must be strictly followed, and data securitization be given utmost importance.
- **Need for medical expertise**: The diagnosis and transmission of medical data to healthcare providers is governed by regulations. The inability to interpret data captured by medical devices, with patients trying to diagnosis themselves based on an incorrect understanding, can lead to major risks. Every diagnosis and prognosis bases itself not only on current observations made by devices, but on the history and the health profile of the individual

patient. Diagnosis and detection of alert conditions is aided by automated decision support systems where rules/decision trees are provided by trained physicians, customized for each condition and patient.

- **Research Methodology & Proposed work:**

  Proposed Health Monitoring System: -

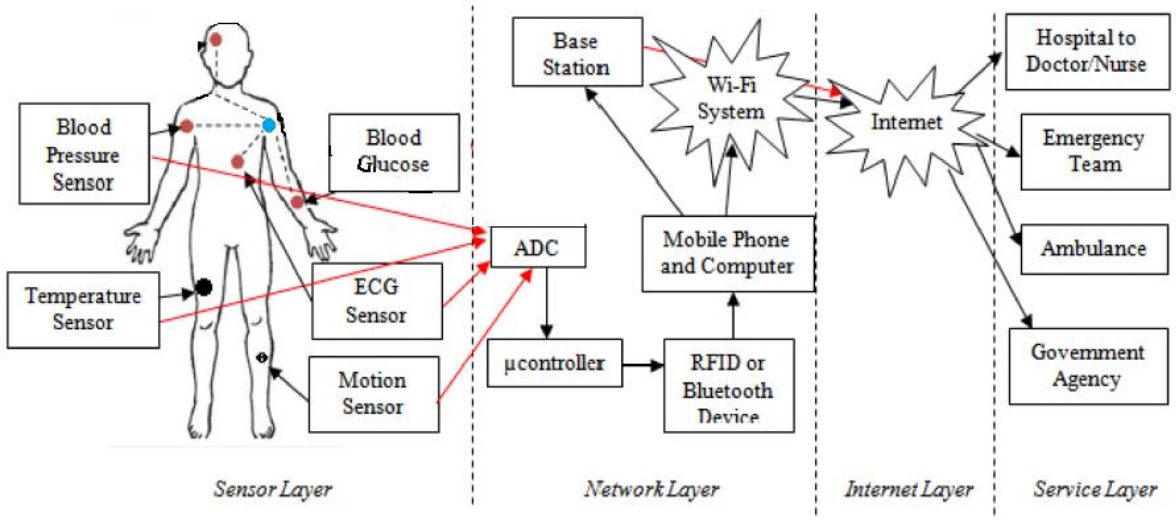

Figure 1:Proposed Wireless Sensor Network Based Health Monitoring System

WSN based real- time health monitoring system comprises association between micro controller and actuator to procure faithful estimation, real-time monitoring and evaluating the cases condition eventually grows the strength of this technology in healthcare. Proposed framework contains ECG sensor, Blood Pressure sensor, temperature sensor, Motion sensor and Blood Glucose sensor. The combination of micro controller with the smarts sensors offers advantages like as incorporated precision analog capabilities, small power consumption and easy for designing GUI's. The Figure 1 shows patients healthcare model by using WSN. It consists of the sensors which are attached to human body, Microcontroller, Analog to digital converter (ADC), wireless devices like as Bluetooth, RFID, Mobile Phones, Wi-Fi system, Internet devices and doctors/nurses, hospitals, emergency team, Ambulance, Government Agencies, etc. which provides the facility to the *Sensor Layer* patients for their healthy fare. The sensors continuously collect the real-time information from the patient's body to get the patient details. In case of any emergency, these wireless devices can distantly report the physical condition of the patient to his doctors and/or relatives. In such condition

the doctors and hospitals can respond with emergency medical services such as ambulance or provide the necessary actions to the relatives for aiding them to help the patients.

These real-time signals generated from these sensors are in analog form making it necessary to be converted into digital form for which ADC is used. These digitalized signal form the ADC are forwarded to RFID/Bluetooth device through microcontrollers. RFID/B1uetooth devices wirelessly transmits these signal to the mobile phone for the transmission of data through internet to the specific destination. The internet either uses the base station or internet for the transmission purpose. All these operations can be done into four different layers and providing different services to each other for combined functioning as shown in Figure 1.

Sensor layer contains signal conditioning and these sensors are wired with ADC to give real-time information to micro-controller. In Network layer, proposed WSN open system framework helps to transmit these signals to internet via Bluetooth to mobile phone or computer. Internet layer has apache server which dynamically accepts data from client side as well as maintains low byte consumption to avoid data charges as show in Figure 2. Finally, service layer analyses these real-time information and take action as per patient's health situation.

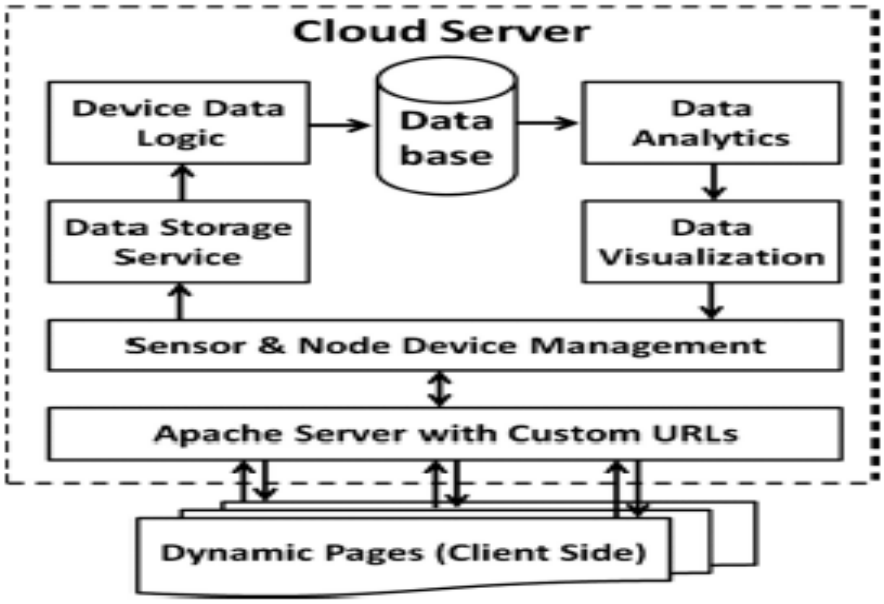

Figure 2: Wireless Sensor Network's Cloud Server Architecture

Cloud Server for Data Storage: -

The collected user's data is communicated to a cloud server which is responsible for facilitating the accessibility of such a data anywhere through the Internet. The cloud server implements a wide set of data management services including data storage, data analytics,

and data visualization in addition to providing an appropriate application program interface (API) and software tools through which the data can be accessed and manipulated. Our implementation of the cloud server is shown in Figure 2. The cloud server core is a large database that has enough space to accommodate the huge amounts of data for the different sensors for long times to track the history of the system user. The database is interfaced to a wide set of data analysis algorithms and APIs such as Google Sheets for data visualization. Data can be accessed through the Internet using dynamic webpages as shown in Figure 2.

- **Conclusion:**

In this synopsis, a wide range of smart health monitoring systems, their applications and efficiency have been identified and discussed. A number of studies supported the effectiveness of such systems both in a hospital setting as well as the home environment. Standardization of and demand for such systems and the applications of telemedicine are a fast growing area for research. For instance, a vital signs transmission system, based on VITAL standards for telemedicine applications have already been developed [10]. It was identified that online monitoring and real-time transmission of bio-signals, and related systems require high quality signals without artefacts to be capable of operating without delay. Online or web based monitoring systems are playing a major role in remote patient monitoring producing high quality data and accuracy. However, the level of monitoring required by medical professionals from remote or online communication is significantly greater than the HMS are currently capable of delivering. Most remote systems monitor vital signs; collate them in a remote station such as a laptop, PC or local server for processing and transmitting to different devices, thereby incurring delays and/or alerts only in emergency situations.

Medical staff use this limited information as initial data and starting point for interventions. Panescu [11] identifies several commercial wireless remote monitoring systems and stipulates the requisite design factors. These include power consumption, communication range, size, cost and security. Moreover, HMS systems are dependent on the internet (connectivity and speed) or mobile communications (transfer rate and signal strength) using GPRS or 3G. Development of new generation 4 G and 5 G infrastructure for a mobile devices is also proposed. Like any other technological advancement, smart health monitoring systems have both benefits and limitations and currently, there is on-going research to improve these systems. Another challenging aspect in the field of HMS is to design further clinical trials to

ascertain the effects of monitoring different patient groups according to age, ethnicity, gender and disease specific.

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